In-situ and Land-Based Remote Sensing of River Inlets and Their Interaction with Coastal Waters

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LONG-TERM GOALS

Principal research goals are to develop tools for characterizing the physics of river flow through a coastal inlet, surface wave processes, and the fate of the plume within the coastal ocean.

OBJECTIVES

In-situ and land-based remote sensing of the New River inlet and its interaction with coastal waters objectives include:

- Identify processes controlling the flow of the river through and within the inlet.
- Characterize wave breaking within the inlet as a result of shoaling and wave-current interactions.
- Understand the fate, dilution, and transport of the river plume as it discharges into the ocean.
- Learn how to use and exploit X-Band radar / unmanned sensors in the river inlet environment.

APPROACH

An array of instrumentation was deployed on land, on the sea surface and below the sea surface to characterize the air-sea-land interactions that control the river inlet dynamics. Specifically:

- An X-band marine radar system measured backscatter (HH polarization) at a 3m range resolution out to approximately 5km, at 42RPM in 1/12th degree steps (Figure 1).

Report Documentation Page

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Figure 1. Left Panel: The Scripps self-contained X-band marine radar system mounted on a 4-wheel drive van supported "off grid" unique backscatter measurements at the New River Inlet. Right Panel: Overlay of radar backscatter with background satellite image (Google) and H hyperspectral overflight image collected by F.Feddersen on 5/8/2012.

- A five buoy drifting array (miniature wave buoys) was deployed on both ebb and flood tides to map the velocity and wave conditions within the inlet (Figure 2). Data were processed for both Lagrangian drift velocity and for surface wave conditions, including the directional wave spectrum using the high-frequency buoy motion that is sampled at 10Hz. The GPS positioning and timing allowed the drifter data to be compared with the radar backscatter.

Figure 2. Left Panel: A portion of the miniature wave array deployed to drift across shoals. Right Panel: 10Hz (x,y,z) inertial and GPS data sampling from miniature wave buoy array.

- A cross-shore array of meteorological buoys that extended from the shoreline to offshore approximately 6km (Figure 3). The buoys sampled the wind field continuously at 1Hz and supported both the ground-based observations and the satellite remote sensing components of RIVET by PI Graber and others.

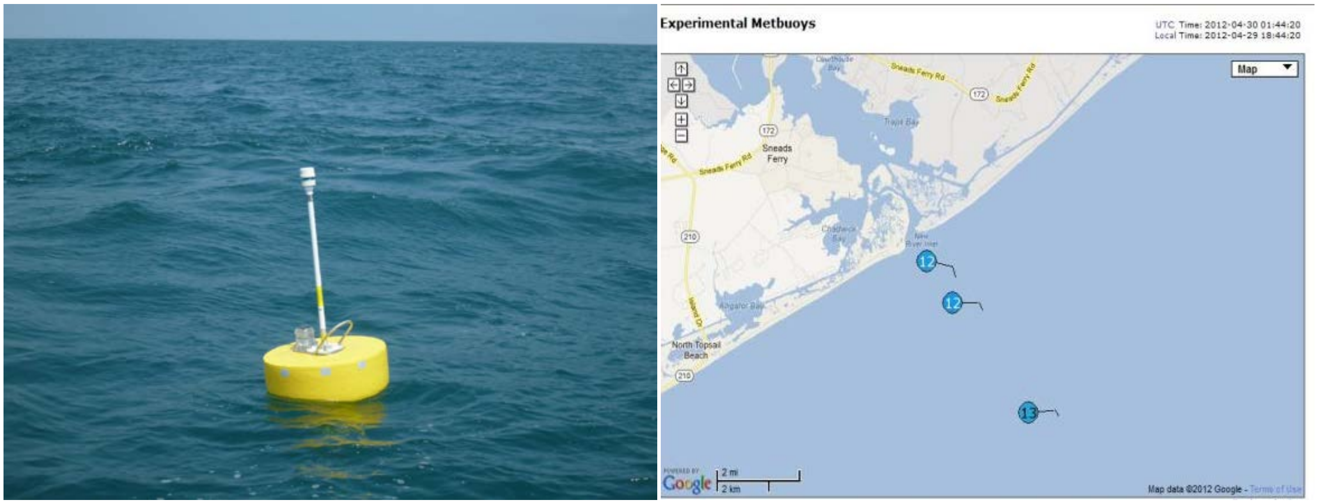


Figure 3. Left Panel: Deployed meteorological buoys measured wind speed/direction, GPS, air and sea temperature. Right Panel: Buoys deployed in cross-shore array, with shoreline values measured at radar site.

- A Remote Environmental Sampling Units (REMUS) 100 Unmanned Underwater Vehicle (UUV) equipped with optical (CDOM, optical backscatter) and physical sensors (ADCP, CTD) was repeatedly deployed at the mouth of the inlet to map the plume created by the outgoing tide (Figure 4). Dye releases managed by RIVET PIs Feddersen and Guza were also mapped with the REMUS using a dye-tuned flouorometer.

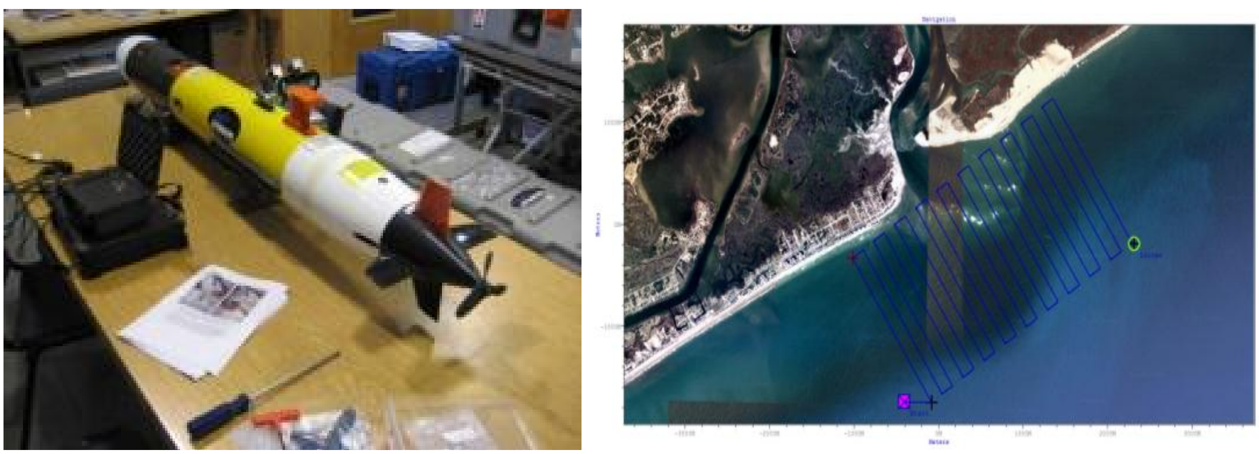


Figure 4. Left Panel: REMUS UUV with CTD, sidescan, bottom look sonar, ADCP, CDOM, backscatter and dye tuned flourometer. Right Panel: Sample mission profile depicted with blue line.

WORK COMPLETED

The following sensors were successfully deployed and operated during the entire May 2012 field test period:

- A self-contained X-band radar system was deployed on the Camp Lejune side of the property at a ~ 15m elevation. Backscatter data was collected with HH polarization to a range of 3.5km, 3m range resolution, and with 0.08 degree azimuthal steps at a rotation rate of 42RPM. Ten Terabytes of

data were collected spanning a range of wind/wave directions. A meteorological station was also operated on the radar tower. The radar data is being analyzed to:

  - Characterize the spatial gradients of the wave field outside and within the shoaling region of the inlet.
  - Characterize the shoal location and their movement through time averages of backscatter which are a good measure of the intense and persistent breaking occurring on the shoals.
  - Attempt to retrieve a high resolution spatial current map within the inlet through cross-correlation techniques and wave-current interaction inversions.
  - Track bathymetry changes through inversions of the radar data.

- An array of self-contained, miniature directional wave buoys was deployed on outgoing and incoming tides to measure the gradients of the surface wave field and characterize the Lagrangian currents of the inlet. Drifters were purposefully deployed over the shoals to characterize the changes in wave conditions across those regions. Typically five buoys were used in each deployment, and approximately 20 days of data were collected. The data are being used to both understand the radar backscatter and to characterize the waves within the study site.

- A REMUS AUV equipped with dye-tuned flourometers, sidescan sonar, ADCP, and optical sensors for CDOM, Chlorophyll, and backscatter (660nm) was operated both within the channel and immediately at the inlet entrance. The vehicle was operated in modes to both track the released dye (during the release days) and to characterize the offshore jet and natural optical signals of the plume water.

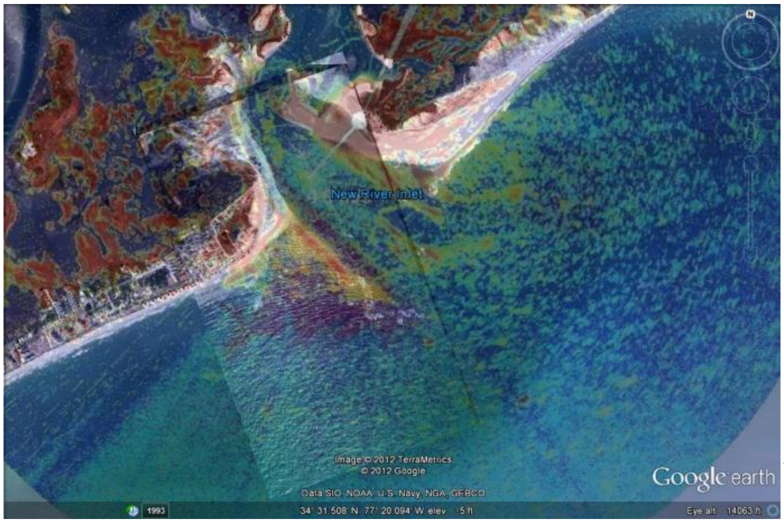
- Three bottom packages with ambient sound recorders (100Hz-10kHz) and pressure sensors were deployed on the seafloor within the field of view of the radar. These systems were deployed to both monitor man-made noise (boat traffic) and to characterize the wave breaking through the radiated noise of bubbles generated by the breakers.

- Three metbuoys were deployed in a cross-shore array starting from the inlet entrance offshore to 6km. The buoys were used to characterize the wind fields in the footprint of the radar, as well as measure the cross-shelf gradients of the wind forcing.

RESULTS

We are presently processing the data obtained from the May 2012 RIVET I field study. Example results are provided in Figures (5-7). Meaningful technical issues under review include:

- Tackle challenges of radar data interpretation in regions of gradients: Current, wave, bathymetry inversion. Conducting these studies in areas of high radar variability due to small scale breaking.
- Quantify spatial gradients of wind field in collaboration with modelers and satellite remote sensing.
- Investigate mixing processes associated with the river inlet jet using the REMUS AUV measurements of both the dye and natural tracers (eg. CDOM, salinity, optical backscatter).
- Investigate wave gradients as measured by buoys, i.e. breaking processes. Investigate bathymetry inversion.
- Derive surface currents from X-Band Radar.



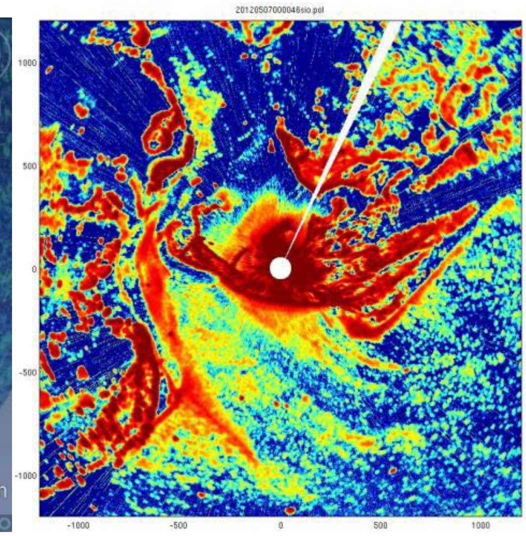


Figure 5. Left Panel: A map of the New River Inlet, radar backscatter measured by our shore based radar, and an airborne hyperspectral image provided by Feddersen. Right Panel. A time-average of the backscatter that indicates the land boundaries shoals with wave breaking and navigation channels.

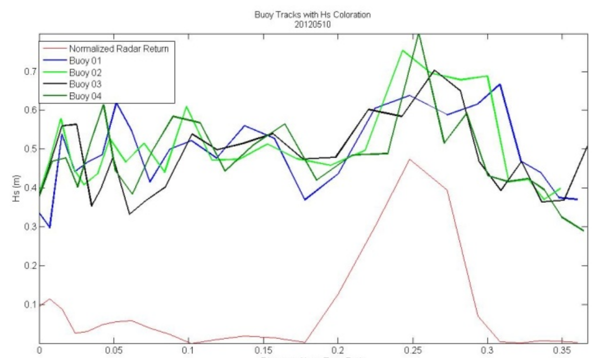


Figure 6. Left Panel: Drift tracks of wave buoys deployed at the study site. Drifters were released to map waves across the channel. Right Panel: Significant wave height mapped by the drifters as they passed across the southern shoal. Also shown is a short time average of the radar backscatter, with the high backscatter occurring at the region of highest Hs.

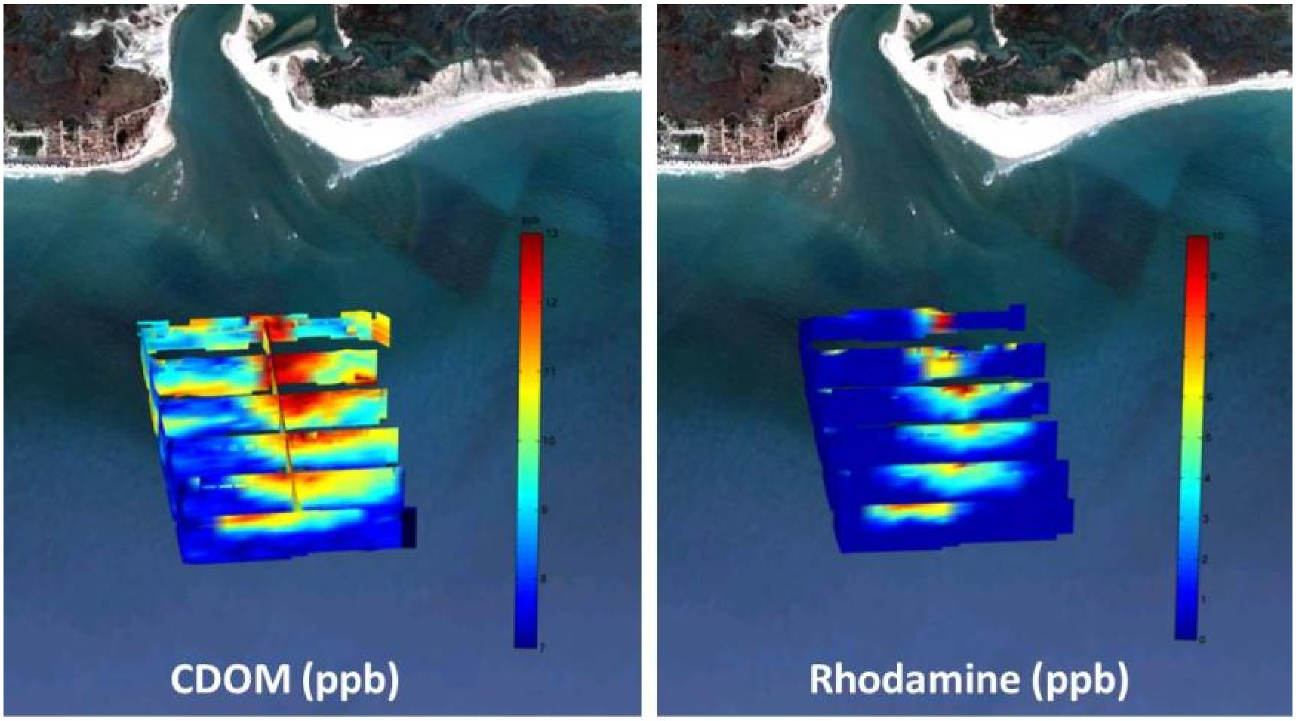


Figure 7. REMUS data of cross-sections of the outgoing tidal jet at the New River Inlet. The gridded data is from a series of sections surveyed by the AUV as it was programmed to cross the jet. Left Panel: Colored Dissolved Organic Matter, a natural tracer characteristic in land-based discharges. Right Panel: Concentrations of rhodamine dye, also sampled by the vehicle. Both the natural and introduced tracers will be analyzed to measure the transport and mixing processes within the outgoing jet.

IMPACT/APPLICATIONS

A naval relevant output of our observational program will be the development of sensing methods that could transition to future naval capabilities. Development of observational techniques suitable for sensing river inlet processes not only provides a pathway for both improving and validating forecast models and for developing sensing strategies to support Navy and USMC expeditionary operations. These include METOC predictions for beach landings and breachings, light and sound propagation models for mine detection, mine burial predictions, and identification of hazards for combat swimmers, divers, small boat, and helicopter operations. Detection and tracking of river plumes is also of practical interest for purposes of environmental and pollution regulations on military facilities including prediction of beach water quality and coastal transport of upstream industrial byproducts. We anticipate being in a better position to predict specific applications to Naval science issues once our analysis of the field data is complete.

RELATED PROJECTS

- Environmental Sensing Motion Forecasting
- Vietnam River Deltas program
- Tropical Ocean Prediction and Island Circulation studies in the Republic of Palau.